The three integration lower limits, μ, on page 893 are not misprints. However, the brackets should be closed in front of the exponential factor in the second equation for w, and the last equation on page 894 should read $w=\phi+3.2kT$.

[1] G. M. Fleming and J. E. Henderson, Phys. Rev. **58**, 887 (1940).
[2] J. E. Henderson and R. K. Dahlstrom, Phys. Rev. **55**, 473 (1939).

On the Selection Rules in Beta-Decay

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April 25, 1941

THE rapid decay of a presumably largely ^1S He^6 to a $^3S+^3D$ Li^6 has always been regarded as strong evidence for the Gamow-Teller selection rules in beta-decay. The analogous disintegration $C^{10}\rightarrow B^{10}$ is also rapid and obviously allowed. However the three further at first sight similar disintegrations

$$(S)\qquad H+H\rightarrow D;\quad Be^{10}\rightarrow B^{10};\quad C^{14}\rightarrow N^{14},$$

where in every case the parent nucleus would be expected to be largely ^1S, and the product nuclei are known to be predominantly $^3S+^3D$, are slower than would be expected for allowed transitions of the observed energy by factors of the order 10^4-10^7. The activity $O^{14}\rightarrow N^{14}$, homologous to that of C^{14}, is not known; the activity of F^{18}, where normal states can perhaps be less unambiguously assigned, is allowed.

The assumption that the initial states in the disintegrations (S) have been incorrectly assigned is very unsatisfactory. For the reaction $H+H\rightarrow D$ there can be no question that the initial state is ^1S; and the astrophysical evidence that this reaction is slow seems excellent. For Be^{10} and C^{14} states of very high angular momentum (^1G) would be required to account, with Gamow-Teller selection rules, for their extremely long life; this is not only highly implausible on the basis of any known nuclear theory, but in gross contradiction with the expected proton-neutron symmetry of the nuclei C^{10} and Be^{10}. Almost equally unsatisfactory is the assumption that He^6 and C^{10} are ^3S or ^3D, and the Gamow-Teller selection rules wrong; for this too, in addition to leaving unexplained the many less direct evidences for spin change in allowed transitions, would grossly violate theoretical expectations on the symmetry of normal states and on the proton-neutron symmetry in C^{10} and Be^{10}.

The fast reactions

$$(F)\qquad He^6\rightarrow Li^6;\quad C^{10}\rightarrow B^{10}$$

differ from the slow reactions (S) systematically, in that for (F) energies of over 3 Mev are available, whereas for (S) the energies are 350 kev, 550 kev, and 150 kev, respectively. This suggests that the Gamow-Teller selection rules have a "threshold," such as would be involved if the corresponding neutrino had a rest mass. This rest mass would have to be at least of the order of that of an electron, and might for instance characterize a neutrino of spin $\frac{3}{2}$. On this theory the reactions (S) would be governed by Fermi selection rules, and there would then be no difficulty, on taking into account the small amount of ^3P to be expected in the initial states, and of ^1P in B^{10} and N^{14}, in accounting for their very long lifetimes. The reactions (F) on the other hand would involve the emission of a heavy neutrino and be allowed by Gamow-Teller selection rules.

This suggestion has three simple consequences: (I) There should be a discrepancy, given by the mass of the heavy neutrino, in the energy balance of the reactions (F).[1] (II) The shape of the upper end of the He^6 and C^{10} spectra should correspond to a finite neutrino mass. (III) The disintegration $O^{14}\rightarrow N^{14}$, that has an estimated upper limit 3.8 Mev$-\mu c^2$, with μ the heavy neutrino mass, should decay rapidly. If we take N^{14} as 15 percent ^3S, and $\mu c^2\sim\frac{1}{2}$ Mev, the lifetime should be about 20″.[2]

It would appear that published evidence was neither sufficient to check nor disprove these expectations. If we suggest the *a priori*, highly improbable existence of the heavy neutrino, it is in part because these three points can so readily be settled, but even more again to call attention to the very puzzling difficulties that have arisen in interpreting these activities.

[1] The Wigner and Hartree estimates of the $C^{10}-Be^{10}$ Coulomb difference themselves differ by several hundred kilovolts, and are presumably of insufficient accuracy to afford a test of the C^{10} energy balance.
[2] The bombardment of C with alpha-particles, of N with deuterons, both lead to strong O^{15} activity; the bombardment of N with protons leads to a strong C^{11}. All these reactions have been tried in Berkeley, by Dr. Kamen, Dr. Segrè, and Mr. Wright, as sources for O^{14}; in every case the results of a preliminary survey were negative. These investigations are not yet concluded, and I am grateful to these workers for telling me of their findings.

Non-Laue Diffraction Maxima from Rocksalt—Non-Equatorial Maxima

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May 15, 1941

PROFESSOR W. H. Zachariasen has been kind enough to send the senior author a copy of his Letter to the Editor which appears in this issue of *The Physical Review*. Non-equatorial associated Bragg spots appeared on the films which were used in Jauncey and Baltzer's paper.[1] A correction for the position of these spots on the film must be made if the l axis of the crystal and the axis of the cylinder of photographic film are not parallel. Making this correction, which will be described later, we find the experimental shifts, $2\theta_m-2\theta_B$, shown in the second column of Table I. The shifts are for the 402 associated Bragg spots

Table I. *Values of* $2\theta_m-2\theta_B$.

Δ	Exp.	Formula Orig.	Formula Rev.
−3°20′	−1°19′	−2°29′	−1°37′
−2°25′	−0°55′	−1°48′	−1°10′
−1°39′	−0°47′	−1°14′	−0°48′
−0°44′	−0°09′	−0°33′	−0°21′
+0°12′	−0°00′	+0°09′	+0°06′
+1°01′	−0°28′	+0°45′	+0°29′
+1°49′	−0°45′	+1°21′	+0°52′